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Metazoan Endoparasites of the Gray Fox, *Urocyon cinereoargenteus* from New Mexico

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Abstract

Metazoan gastrointestinal endoparasites were recovered from 10 of 14 (71.4%) gray foxes [*Urocyon cinereoargenteus* (Schreber, 1775)] collected in New Mexico from 1996 -1998. They include a pentastome *Porocephalus sp.,* (n=1, 7.1%), a trematode: *Fasciola hepatica* Linnaeus, 1758 (n=1, 7.1%), the nematodes: *Physaloptera rara* Hall and Wigdor, 1918 (n=3, 14.3%), *Physaloptera praeputialis* Linstow, 1899 (n=2, 14.3%), an unidentified female *Physaloptera* sp. (n=1, 7.1%), *Toxocara mystax* (Zeder, 1800) (n=2, 14.3%), *Toxocara canis* (Werner, 1782) (n=1, 7.1%), *Spirocerca lupi* (Rudolphi, 1809) (n=6, 42.9%), and cestodes: *Taenia pisiformis* (Bloch, 1780) n=3, n=3, (21.4%), *Taenia serialis* (Gervais, 1847) (n=3, 21.4%), and *Mesocestoides kirbyi* Chandler, 1944 (n=7, 50%). All parasites found are new records for the gray fox in New Mexico. The parasites, *Porocephalus* sp, *Fasciola hepatica, Toxocara mystax* and *Mesocestoides kirbyi* are new records for the gray fox for North America.

Keywords: Gray fox, *Urocyon cinereoargenteus,* New Mexico, *Porocephalus* sp. *Fasciola hepatica, Physaloptera rara, Physaloptera praeputialis, Toxocara mystax, Toxocara canis, Spirocerca lupi, Taenia pisiformis, Taenia serialis, Mesocestoides kirbyi, Spirocerca lupi*

The gray fox, *Urocyon cinereoargenteus* (Schreber, 1775) has a wide-ranging distribution in the Nearctic (Hall and Kelson, 1959) and occurs throughout New Mexico in woodland and rocky habitats (Findley et al., 1975). Fourteen gray foxes were collected in New Mexico from 1996 -1998 as part of an effort by the New Mexico Department of Game and Fish (NMDGF) to document the distribution of foxes in the state. Records of the fleas from these same animals were published by Harrison et al. (2003). Prior to the current paper, there have been no other reports of metazoan endoparasites of the gray fox in New Mexico. We report here on the metazoan endoparasites collected in gray foxes as part of this survey.

Materials and Methods

Most of the foxes were obtained from road-kills, but a few were shot or poisoned with M-44 by the Wildlife Services, Animal and Plant Health Inspection Service, US Dept. of Agriculture. Foxes were placed in plastic bags and frozen until they could be examined in the laboratory. The gastrointestinal tract, heart, and trachea were opened and the contents examined and endoparasites were picked from dissected animals. Helminths and a pentastome were preserved for study in 70% ethanol. Nematodes were later cleared and studied in glycerine or warmed lactophenol and then returned to the preservative. Cestodes were stained in carmine and mounted

in Canada balsam for identification. The trematode and pentastome were examined in alcohol preparations. All foxes collected during this study are deposited in the Division of Mammals in the Museum of Southwestern Biology (MSB) The University of New Mexico, (UNM) Albuquerque, New Mexico, U.S.A. The host and parasite specimens are available for examination upon written request to the UNM MSB Division of Mammals. Voucher specimens were deposited in the Manter Laboratory Parasite Collection as follows: *Fasciola hepatica* (Linnaeus, 1758) [HWML66665], the pentastome, the cestode *Mesocestoides kirbyi* Chandler, 1944 [HWML49501] and the nematode *Toxocara mystax* Zeder 1800 [HWML66666] are deposited in the parasite collection of the Harold W. Manter Laboratory of Parasitology (UNSM), University of Nebraska State Museum, Lincoln, Nebraska.

Results

Ten of the 14 foxes (79%) contained parasites. Four female foxes without parasites (21.4%) were collected from Otero, Santa Fe and Lea counties. A pentastome, a trematode, three species of cestodes, and five species of nematodes were recovered at time of necropsy of the foxes (Table 1).

Pentastomes

A single specimen of the crustacean *Porocephalus* Humboldt, 1811 was found in a single fox collected from Guadalupe County. Species of *Porocephalus* are parasites of snakes and *P. crotali* is present in rattlesnakes in North America (Riley, 1981). Esslinger (1962) experimentally demonstrated the life-cycle and used white mice as intermediate hosts. When rodents that are infected with pentastome nymphs are eaten by *Crotalus* spp. the nymphs are released from the rodent in the digestive system, penetrate the intestine, and mature in the lungs feeding on tissue fluids and blood. Layne (1967) reported rodents infected with nymphs in Florida and listed: *Peromyscus floridanus* (Chapman, 1889) (0.6%), P. *gossypinus* (Le Conte, 1853) (4.3%) and *Sigmodon hispidus* (0.2%). Riley (1981) also reported pentastomes in western Diamonback rattlesnakes (*Crotalus atrox* Barid and Girard, 1853) The presence of a single adult pentastome in the intestine found in our study suggests that the fox preyed upon a rattlesnake and the adult pentastome was ingested with the meal or a nymph was obtained when a rodent was eaten. This is the first record of a pentastome in the gray fox.

Trematodes

One specimen of *Fasciola hepatica* Linneaus, 1758 (HWML66665) was collected from a single female fox in San Juan County. This trematode is an important parasite of domesticated livestock but has been reported from other mammals including rodents, rabbits, pigs, deer, dogs and other carnivores (Ulmer, 1975). Olson (1948) found that wild rabbits served as reservoir hosts of *F.*

Table 1. Parasites (●) recovered from each gray fox (*Urocyon cineroargenteus*) collected within New Mexico are categorized by the host's collection number, sex, and the county from which the host was collected. Parasites include: *Fasciola hepatica,* Pentasome sp.*, Mescestoides kirbyi, Taenia pisiformis, Taenia serialis, Spirocerca lupi, Toxocara canis, Toxocara cati, Physaloptera praeputialis, Physaloptera rara, and Physaloptera* sp.

Fox #	Sex	County	*F. hepatica*	Pentasome	*M. kirbyi*	*T. pisiformis*	*T. serialis*	*S. lupi*	*T. canis*	*T. cati*	*P. praeputialis*	*P. rara*	*P.* sp
6166	F	Lea											
6174	M	Lea			●				●			●	
6182	F	Harding			●	●	●	●		●	●	●	
6204	F	Lea			●		●	●					
6205	M	Mora											●
6206	M	Otero											
6221	M	Quay			●		●	●					
6222	M	Santa Fe											
6223	F	Santa Fe											
6225	F	San Juan	●		●	●		●					
6226	F	San Juan			●	●							
6227	F	Colfax						●					
6238	M	Catron						●					
6239	M	Guadalupe		●	●					●	●		

hepatica in southern Texas. Since only a single trematode was present in the intestine it seems likely that it was obtained from a recent meal. This is the first report of this trematode in the gray fox.

Other trematodes from the gray fox include *Alaria americana* (Walton, 1949) from southern Illinois by Dyer and Klimstra (1982) and from South Carolina by Davidson et al. (1992); *Alaria canis* La Rue and Fallis, 1934 from Minnesota by Erickson (1944); *Alaria marcianae* (La Rue, 1917) from Florida by Conti (1984) and Forrester (1992); *Alaria arisaemoides* Agustine and Uribe 1927; *Alaria intermedia* (Oliver and Odlaug, 1938) from Massachusetts by Rankin (1946); *Paragonimus kellicotti* Ward, 1908 from West Virginia by Davidson et al. (1992a); *A. canis, Procyotrema marsupiformis* Harkema and Miller, 1959*, Eurytrema procyonis* Denton, 1942, and *E. vulpis* Stunkard, 1947 from North Carolina, and *Euryhelmis squamula* (Rudolphi, 1819), *E. vulpis,* and *Sellacotyle mustelae* Wallace 1935 from Georgia by Miller and Harkema (1968), and *E. procyonis* from both southern Illinois by Dyer and Klimstra (1982a) and Maryland by Herman et al. (1957).

Tapeworms

Adult strobilae of *Taenia pisiformis* (Bloch, 1780) were recovered from three foxes (21.4%), a female from Harding County (2 scolexes), and two females from San Juan County, each with a single scolex. *Taenia serialis* Gervais, 1847 was also recovered from three foxes, (21.4%), including a female from Harding County (4 scolexes), a female from Lea County (1 scolex), and a male from Quay County (only proglottids). Hall (1920) reported *T. pisiformis* from gray foxes. Stiles and Baker (1935) reported *Diphyllobothrium* (possibly *D. latum*), and *Taenia* (possibly *T. pisiformis*) from the gray fox. Both tapeworm species were reported from gray foxes in Texas by Buechner (1944) who found that *T. pisiformis* was the most common tapeworm encountered with 56.7% of animals infected but *T. serialis* was not common, with only 5.5% of animals examined harboring this species. Miller and Harkema (1968) reported *Taenia pisiformis*, from grey foxes from North Carolina, South Carolina, and Georgia. Erickson (1944) reported *Multiceps serialis* (Gervais, 1847)from gray foxes in Minnesota. Hall (1919) reported *T. pisiformis* from a gray fox. MacGregor (1942) reported *Taenia (*possibly *pisiformis*) and an unidentified *Taenia* sp. from gray foxes in Massachusetts. Rankin (1946) found *T. pisiformis* in a single gray fox from Massachusetts. Erickson (1944) reported *T. pisiformis* (58%) and a *Taenia* sp. from gray foxes in Minnesota. Dyer and Klimstra (1982) report *T. pisiformis* as the most common parasite in gray foxes from Southern Illinois. Conti (1984) reported *T. pisiformis* in 4 % of gray foxes from Florida. He also found two other *Taenia* spp., one of which resembled *T. macrocystis* (Diesing, 1850) see also Forrester (1992). Ward (1947) found 15 of 17 (88%) of gray foxes from Mississippi infected with *T. pisiformis*. Davidson et al. (1992) found *Taenia crassiceps* and *Taenia pisiformis* in South Carolina. Buechner (1944) examined 80 gray foxes from Harrison Co., eastern Texas and Kerr and Mason counties from central Texas. He reported the tapeworms *Taenia pisiformis*, and *Taenia serialis*. Erickson (1944) reported a *Taenia* sp. in 12.9% of gray foxes from Minnesota. The life cycle of *T. pisiformis* involves various species of hares, *Lepus* spp. and rabbits *Sylvilagus* spp.

In the current study, *Mesocestoides kirbyi* Chandler, 1944 was the most common tapeworm obtained. It occurred in 7 foxes (50%) collected in Lea county (male with 1 scolex; female with 4 scolexes), Harding county (female with 245 scolexes), Quay county (male with 5 scolexes), San Juan county (female with 76 scolexes and a second female with 209 scolexes), and Guadalupe county, in a male that harbored 15 scolexes. The specimens of *Mesocestoides* observed here closely resemble *M. kirbyi* Chandler, 1944 from *Canis latrans* Say, 1823 in California that has bell-shaped gravid segments. The bell-shaped segments in our specimens average 1.36 mm wide and 1.9 mm long from the edges of the bell and 0.90 mm long from the posterior indention to the next proglottid. The parauterine organ is round, averaging 0.68 in diameter with an egg mass average of 0.24 mm in diameter. Shults (1970) reported *M. kirbyi* as a parasite of coyotes, *Canis latrans*, red foxes *Vulpes vulpes* (Linnaeus, 1758) wolverine, *Gulo gulo* (Linnaeus, 1758)*,* and the lynx, *Lynx canadensis* Kerr, 1792 in Alaska and tetrathyridia were found in a red-backed vole, *Clethrionomys rutilus* (Pallas, 1779) also from Alaska. Based on field-based collections of *M. lineatus* and experimental infections of *M. kirbyi*, Shults (1970) redescribed and illustrated both species.

Buechner (1944) reported *Mesocestoides litteratus* (Batsch, 1786) in the gray fox in Texas. Mueller (1927) described *Mesocestoides variabilis* Mueller 1927 from *Urocyon cinereoargenteus californicus* Mearns, 1897 from California. Voge (1953) reported *Mesocestoides variabilis* in gray foxes from California and reported a tapeworm resembling *M. manteri* Chandler (1942) from *Urocyon littoralis* (Baird, 1858) from Santa Barbara, California. She reported tetrathyridia of *M. variabilis* from various lizards and snakes from California. Miller and Harkema (1968) reported *M. variabilis* from gray foxes from North Carolina, South Carolina and Georgia. *Mesocestoides jonesi* Ciordia, 1955 was described from a gray fox in Tennessee by Ciordia (1955). *Mesocestoides variabilis* was

reported to occur in small percentages of gray foxes in southern Illinois by Dyer and Klimstra (1982). Buechner (1944) examined 80 gray foxes from Harrison Co. in eastern Texas and Kerr and Mason counties from central Texas and reported the tapeworm *M. litteratus*. Conti (1984) reported *Mesocestoides* sp. in gray foxes from Florida, see also Forrester (1992). Chandler (1942) reported on a human infection of *Mesocestoides*. Chandler (1942) described *M. manteri* from a Lynx. Voge (1953) considered that *M. manteri* to be a dwarf form of *M. variabilis*. Miller and Harkema (1968) and Dyer and Klimstra (1982) all consider that the epithet *variabilis* should be retained for all these species (ie. they should be synonyms of *M. variabilis*. The terminal gravid proglottids of *M. variabilis* are rectangular and not bell-shaped. On the basis of the bell-shaped terminal proglottids, the measurements of the egg mass and the paruterine organ, we refer our specimens to *M. kirbyi* which is a new record in the gray fox although, it has been reported from other foxes, including *Alopex lagopus ILinnaeus, 1758), Vulpes vulpes, V. v. fulva* (Desmarest, 1820)*, V. corsac* (*Linnaeus, 1768)* as listed by Schmidt (1986). *Mesocestoides litteratus* and *M. variabilis* were listed by Erickson (1944) as parasites of the gray fox. Conti (1984) reported *Mesocestoides* sp. from Florida. Ubelaker et al (2013) reported *M. variabilis* from the red fox *V. vulpes* from New Mexico. Ubelaker et al. (2014) reported *M. variabilis* from kit foxes *V. macrotis* and Ubelaker et al. (2014a) found it in swift foxes *V. velox* (Say, 1823) in New Mexico.

Other records of tapeworms in gray foxes include *Oochoristica mephitis* Skinker 1935 and *Dipylidium caninum* (Linnaeus, 1758) from Massachusetts by Rankin (1946). *Diphyllobothrium* sp. (*latum*) by Stiles and Baker (1935), and Erickson (1944). *Multiceps packii* Christensen, 1929 was reported from Minnesota by Erickson (1944). Miller and Harkema (1968) reported spargana of *Spirometra mansonoides* Mueller, 1935 from gray foxes in North Carolina, South Carolina, and Georgia. Finally, Conti (1984) reported *S. mansonoides* from gray foxes in Florida, see also Forrester (1992).

Nematodes

Genus *Physaloptera* Rudolphi 1819

Physaloptera rara Hall and Wigdor, 1918 (14.3%) was recovered from the stomach and small intestine of a male fox from Lee County (2 specimens) and in a female fox from Harding County (2 specimens). Morgan (1941) reported *P. rara* from a gray fox in Florida. Erickson (1944) found it in 34.2% of gray foxes in Minnesota. Dyer and Klimstra (1982) reported *P. rara* in gray foxes in southern Illinois. Conti (1984) found *P. rara* in 69% of gray foxes in Florida. Buechner (1944) reported *P. rara* in 43 of 112 grey foxes (38.4%) from central Texas but it was absent in foxes from east Texas. Forrester (1992) reported it from Florida. Ubelaker et al. (2014) found it in 43.4% of kit foxes *(V. macrotis*) and Ubelaker et al. (2014a) found it in 35.5% of swift foxes (*V. velox*) from New Mexico.

Physaloptera praeputialis Linstow, 1899 was recovered from a single female fox from Harding County (1 specimen) and from a single male fox from Guadalupe County (5 specimens). A female *Physaloptera* sp. was recovered in a male from Mora County. Chitwood (1931) reported *P. praeputialis* from the gray fox in Virginia (see also Morgan (1941), Erickson (1944). Rankin (1946) reported a *Physaloptera* sp. in gray foxes from Massachusetts and Erickson (1944) in Minnesota. Davidson et al. (1992) recovered *Physaloptera* sp. in gray foxes from South Carolina but Erickson (1944) suggests that this identification is incorrect. Miller and Harkema (1968) reported the nematode *Physaloptera maxillaris* Molin 1860 from gray foxes from North Carolina, South Carolina, and Georgia.

Genera *Toxocara* Stiles 1905 and *Toxascaris* Leiper, 1907

Toxocara canis (Werner, 1782) was recovered from the intestine of a male fox in Lea County (4 specimens). Erickson (1944) reported *T. canis* as a parasite of gray foxes. *Toxocara canis* was reported in 1 of 2 gray foxes from Massachusetts by Rankin (1946). *Toxocara canis* and *Toxascaris leonina* (Linstow, 1902) were both reported from gray foxes by Dyer and Klimstra (1982) from southern Illinois, and Ward (1947) reported *T. canis* from 2 of 17 (12%) gray foxes from Mississippi. Davidson et al. (1992) reported *Toxascaris* sp. and *Toxocara* sp. in gray foxes from South Carolina. *Toxacara mystax* (Zeder, 1800) (HWML 66666) was found in the intestine of a male from Guadalupe County (2 specimens) and female from Harding Count (13 specimens). The current paper is the first report *of T. mystax* from gray foxes.

Spirocerca Railliet and Henry, 1911

Spirocerca lupi (Rudolphi, 1899*)* was recovered from 6 foxes (42.9%), a female from Harding (37 intact specimens and 28 pieces), a female from Lea (1 intact specimen), a male from Quay (1 specimen), a female from San Juan (4 specimens), a female from Colfax (2 specimens), and a male from Catron (3 specimens) counties. Conti (1984) reported it in 12% of gray foxes in Florida. Buechner (1944) found only a single worm in gray foxes from Texas and indicated that it was not an important parasite of the gray fox in Texas. It was also reported by

Erickson (1944) from Minnesota. Buechner (1944) examined 80 gray foxes from Harrison Co. eastern Texas and Kerr and Mason counties from central Texas and reported *S. lupi*. Forrester (1992) reported *S. lupi* from gray foxes in Florida. Ubelaker et al. (2013) found it in red foxes, *V. vulpes* from New Mexico.

Other nematodes from gray foxes but not found in our study include: *Dracunculus insignis* (Leidy, 1858) from the southeastern US by Davidson et al. (1992a), *Ancylostoma caninum* (Erocolani, 1859), Ancylostomidae, and *Uncinaria* Froelich, 1789 (sp.) by Stiles and Baker (1935), *A. caninum, Capillaria* Zeder, 1800 (sp.), *Molineus* Cameron, 1932 (sp.), and *Uncinaria stenocephala* (Railliet, 1884) by Davidson et al (1992). *Uncinaria stenocephala* was also reported from Massachusetts by Rankin (1946). *Dirofilaria immitis* (Leidy, 1856) has been reported from Southern Illinois by Dyer and Klimstra (1982), from North Carolina and South Carolina by Miller and Harkema (1968), from New York by Stone (1974) and Monson et al. (1973), from Louisiana by Crowell et al. (1977), from Indiana by Kazacos (1977) and Kazacos and Edberg (1979), from Michigan by Stuht (1978), from Alabama, Georgia, and Mississippi by Simmons et al. (1980), from Florida by Conti (1984), and from North and South Carolina and Georgia by Miller and Harkema (1968). MacGregor (1942) found nematodes in 12 of 13 gray foxes from Massachusetts and eggs in one gray fox dropping (scat) from MacGregor's study, these nematodes were identified by Dr. J. F. Mueller of the New York State College of Forestry as *Toxascaris (limbata?) = leonina* (Linstow, 1902) and *Physaloptera* Rudolphi, 1819 (sp.). Erickson (1944) reported *A. braziliense Gomez de* Faria, 1910, and *A. caninum* from Minnesota. *Capillaria aerophila* (Crepelin, 1839), *Crenosoma vulpis* (Dujardin, 1845), *Haemonchis similis* Travassos, 1914, *Uncinaria* sp., *Toxascaris leonina*, and *Dracunuclus insignis* (Leidy, 1858) were reported from Georgia by Davidson et al (1992a). Davidson et al. (1992) also reported *Capillaria* (sp.), *A. caninum*, *Molineus* sp., *Toxascaris* sp., *Toxocara* sp., and *Uncinaria stenocephala*. *Molineus barbatus* Chandler, 1942, *A. tubaeforme, Trichuris vulpis* (Froelich, 1789), and the larvae of an unidentified spiurid, *Capillaria aerophila* (Crepelin, 1839) and *Strongyloides stercoralis* (Bavay, 1876) was reported from Florida by Conti (1984). *Ancylostoma caninum, Toxascaris leonina,* and *Trichuris vulpis* were reported from Southern Illinois by Dyer and Klimstra (1982). Forrester (1992) summarized the helminths reported from 26 gray foxes in Florida [including the study by Conti (1984)] and reported these nematodes *Molineus barbatus* (Chandler, 1942), *A. tubaeforme, A. caninum, A. braziliense, T. vulpis,* spiurid larvae, *D. immitis, C. aerophila* and *S. stercoralis*. Miller and Harkema (1968) reported *Molineus patens* (Dujardin, 1845), *A. caninum, C. aerophila, C. plica* (Rudolphi, 1819), and *T. vulpis* from gray foxes in North Carolina, South Carolina, and Georgia. Goble and Cook (1941) examined 12 gray foxes from New York State and reported *Crenosoma vulpis* (Dujardin, 1845) from 2 of them. According to Erickson (1944), Goble reported to him in 1942 that the examination of 88 gray foxes from New York State revealed 15-17% infected by *Crenosoma vulpis* and 6-7% infected by *Capillaria aerophila*. Buechner (1944) examined 80 gray foxes from Harrison Co. eastern Texas and Kerr and Mason counties from central Texas. In addition to records listed above he reported the nematodes *A. caninum, A. braziliense, H. similis*, and *Eucoleus aerophilus* (syn. *C. aerophila*). Conti (1984) reported these parasites from gray foxes in Florida: *Molineus barbatus, A. tubaeforme* (Zeder, 1800), *Trichuris vulpis*, spiruid larvae, *Capillaria aerophila, A. caninum, A. braziliense* and *Strongyloides stercoralis*.

Although we did not find *Acanthocephala* in New Mexico, thorny-headed worms have been reported previously from gray foxes. Erickson (1944) reported *Pachysentis canicola* Meyer, 1931 in gray foxes from Minnesota. Buechner (1944) also reported this acanthocephalan from Texas. Conti (1984) reported an unidentified acanthocephalan in addition to *Centrorhychus wardae* Holloway, 1958, *P. canicola*, and *Moniliformis moniliformis* (Bremser, 1811) from Florida. Forrester (1992) reported *C. wardae, P. canicola, M. moniliformis* and immature forms of either *Oncicola* Travassos, 1916 (sp.) or *Macracanthorhynchus* Travassos, 1917 (spp.) from Florida.

Discussion

Gastrointestinal parasites in wild canid populations have been studied in North America (Erickson, 1944, Samuel et al., 1978 and references therein). Chaddock (1939) evaluated the food habits of foxes in Wisconsin and noted that in 61 of 113 gray fox stomachs (52%), nematodes were found. Our findings show a much reduced parasitic fauna in gray foxes in New Mexico which may be a response to the arid region from where the foxes were collected. Three new parasites are reported here for the first time in gray foxes, including: *Fasciola hepatica*, *Toxacara cati* and an unidentified pentastome. The largest number of parasites recovered was *Mesocestoides kirbyi* with a total of 555 scolexes from 7 animals with 1 host containing 245 scolexes. *Spirocerca lupi* was the second most prevalent parasite with 48 intact specimens and numerous pieces recovered from 6 animals. *Toxocara*

mystax was present in 2 animals totaling 15 specimens. The remaining 7 parasites occurred in smaller numbers with five specimens or less of each parasite within the foxes. The parasite fauna in the gray fox argues strongly for a broad prey base.

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